3.4 NOISE AND VIBRATION

This section identifies potential noise and vibration impacts on sensitive receptors or receivers, such as people in residential areas, schools, and hospitals, for the No Project, Modal, and High-Speed Train (HST) Alternatives. This analysis generally describes the sensitive noise receptors in the five regions and the methodology for determining the potential noise and vibration impacts on those receptors for each alternative. The differences in potential impacts of all three alternatives are compared to each other. This comparison considers the potential noise impacts from airplanes, automobiles on intercity highways, and the proposed HST system. The section also discusses the potential benefits of adding grade separations[1] for existing railroads in some areas, thereby reducing noise generated at grade crossings. Since this is a program-level environmental document, the analysis of potential noise and vibration impacts broadly compares the relative differences in potential impacts between the alternatives and HST alignment options.

3.4.1 Regulatory Requirements and Methods of Evaluation

A. REGULATORY REQUIREMENTS

Noise and vibration are among the environmental issues to be evaluated for a proposed HST project under NEPA and CEQA. The FRA has a regulation governing compliance with the Noise Emission Regulation adopted by the U.S. Environmental Protection Agency (EPA) for noise emissions from interstate railroads. The FRA's Railroad Noise Emission Compliance Regulation (49 C.F.R. Part 210) prescribes minimum compliance regulations for enforcement of the railroad noise emission standards adopted by the EPA (40 C.F.R. Part 201). The FRA has also established criteria for assessment of noise and vibration impacts for high-speed ground transportation projects (U.S. Department of Transportation 1998). The methodology and impact criteria for noise and vibration from the FRA guidance manual have been used in the assessment of the HST Alternative.

Assessment of the components comprising the No Project and Modal Alternatives are based on relevant criteria adopted by the U.S. Department of Transportation Federal Highway Administration (FHWA), Federal Aviation Administration (FAA), and Federal Transit Administration (FTA), each of which has established criteria for assessing noise impacts. As described below, each agency's criteria were used to define a screening distance for assessing the potential for noise impact from relevant sources. The FRA and FTA have also established vibration impact criteria related to rail transportation. The other transportation agencies have not established vibration criteria for the transportation modes under their jurisdiction, airports and highways.

At the state level, the California Noise Control Act was enacted in 1973 (Health and Safety Code § 46010 *et seq.*) and provides for the Office of Noise Control in the Department of Health Services to 1) provide assistance to local communities developing local noise control programs, and 2) work with the Office of Planning and Research to provide guidance for the preparation of the required noise elements in city and county general plans, pursuant to Government Code § 65302(f). In preparing the noise element, a city or county must identify local noise sources and analyze and quantify to the extent practicable current and projected noise levels for various sources, including highways and freeways, passenger and freight railroad operations, ground rapid transit systems, commercial, general, and military aviation and airport operations, and other ground stationary noise sources. Noise level contours must be mapped for these sources, using both community noise equivalent level (CNEL) and day-night average level (L_{dn}) and are to be used as a guide in land use decisions to

[1] For this analysis, a *grade separation* is the literal separation, using overpasses or underpasses, of the rail and roadway components of an at-grade crossing. This separation reduces the need for trains to blow horns at grade crossings and eliminates the need for warning bells.

minimize the exposure of community residents to excessive noise. Airports are subject to the noise requirements set by the FAA and noise standards under C.C.R. Title 21, § 5000.

B. METHOD OF EVALUATION OF IMPACTS

Two basic evaluation techniques were used for this analysis: a screening analysis for each travel mode (highway, air, and HST) and more specific analysis of typologies derived from representative locations for the proposed HST Alternative. The screening analysis for each travel mode provides a basis for a comparison of relative differences in potential noise impacts between the No Project, Modal, and HST Alternatives. The representative typologies were used to verify screening level assumptions and to provide a basis for comparison of HST options, including consideration of the potential effectiveness of mitigation and the potential impacts or benefits associated with grade separation of existing rail lines.

Screening Procedure

Transportation noise impacts are assessed according to the number of people and noise-sensitive land uses potentially impacted by new noise sources from a project. However, for a statewide project such as the proposed HST Alternative (especially before many project-level details have been defined) it is not possible to develop a specific measure of the potential noise impacts because information necessary for performing a detailed noise analysis is not available. Consequently, a screening method was used to develop a general estimate of the relative potential for impact among alternatives. Screening distances were applied from the center of potential alignments to estimate all potentially impacted land uses in noise-sensitive environmental settings. Appendix 3.4-A defines the screening distances used. The number of people and noise-sensitive land uses were tabulated within the defined screening distance. Appendix 3.4-B describes the rating methods used to determine these numbers. The method is conservative in that it overestimates the potential impact. The method identifies all potentially impacted developed lands by type of use within the study area, but subsequent project-level analysis using better-defined system parameters and affected populations is likely to indicate lower levels of potential impact. Because potential noise impacts decrease dramatically if a structure blocks the path to the receptor, this is a conservative approach.

Noise screening analyses were performed for the No Project, Modal, and HST Alternatives. Screening distances were selected for the HST, railroads, highways, and airports based on criteria established by the agencies that regulate these modes.

- FRA and FTA for HST and conventional rail (see Appendix 3.4-C).
- FHWA for highways.
- FAA for aircraft and airports.

The analyses were accomplished using available GIS data for land use and alignment geometry for each alternative. The number of people potentially affected and the area of noise-sensitive land uses within the screening distance were determined using GIS and census data.

The potential impacts were subsequently combined to develop an impact rating for each HST and highway sub-segment assessed for the No Project, Modal, and HST Alternatives (Appendix 3.4-B). The impact rating for each segment is described as low, medium, or high, as an indication of the potential for noise impact.

Application of Screening Method to Highway and Air Modes

Highway noise impact measures used by FHWA are slightly different from the other transportation modes. Highway noise impact is based on the traffic equivalent noise level (L_{eq})

during 1 hour of the day, the hour with the greatest impact on a regular basis. For comparison with the proposed HST Alternative, the potential impacts associated with peak hourly L_{eq} are methodologically equivalent with impacts based on the FRA and FAA modal-specific criteria based on L_{dn} and CNEL. This is because, despite the different ways of measuring noise impacts, the FHWA, FRA, FTA, and FAA criteria are based on similar patterns of negative reaction exhibited by people exposed to gradations of noise from the different transportation modes. Screening distances for highways were calculated for various roadway types by number of lanes, using the FHWA traffic noise model to determine the distance at which the noise contour of 65 A-weighted decibels (dBA) L_{eq} is reached. Highway noise screening distances are described in Appendix 3.4-A.

The screening distances were applied to all of the highway segments that would be improved (additional lanes) under the highway component of the Modal Alternative. In general, the highway-related noise is a function of the volume and speed of traffic (given a representative mix of autos, trucks, and buses) and the road surface. The additional capacity (lanes) added as part of the Modal Alternative would increase both the volume and speed of traffic on the improved highway segments.

Aviation noise was assessed using the CNEL figure used in California, and noise impact would be considered to occur where CNEL exceeds 65 dBA, which is the equivalent to the 65-dBA L_{dn} contour used by the FAA for impact purposes. Noise contours around airports are routinely developed to identify the area and number of people exposed to noise levels in excess of the 65-dBA L_{dn} impact threshold.

For each of the airport improvements (additional gates and runways) that would be part of the aviation component of the Modal Alternative, the 65-dBA L_{dn} noise contour was redrawn and reassessed and overlaid with census data to assess the potential for noise impact. In general, airport noise contours expand around an airport depending on the number of operations of each type of aircraft. A 40% increase in number of flights will result in about a 17% increase in area enclosed by a given noise contour, (i.e., the 65-dBA CNEL noise contour). New runways result in new noise contours, encompassing relatively large areas of previously unexposed land uses—often including homes and other sensitive receptors to aircraft noise. While this area might increase the number of people potentially affected, it would not necessarily increase the severity of potential impact.

Vibration is assumed not to be an issue with highways or aviation primarily because there are no FHWA or FAA regulations that mandate its consideration.

<u>Application of Screening Method to Conventional Rail and High-Speed Train Modes</u>
Railroad noise and vibration criteria developed by FTA are consistent with criteria adopted by the FRA for high-speed trains. They were used to assess conventional rail operations in the No Project and Modal Alternatives as well as the HST Alternative.

Criteria for HST noise impact assessment are based on activity interference and annoyance ratings developed by EPA. These criteria, described and presented in graphical form in Appendix 3.4-C, provide the basis for the rail noise analysis procedures used in the screening and the representative typologies (U.S. Department of Transportation 1998).

The screening procedure used by the FRA takes into account the noise impact criteria, the type of corridor, and the ambient noise conditions in typical communities. Distances within which potential impacts may occur are defined based on operations of a typical HST system. These distances were developed from detailed noise models based on empirical measurements of noise emissions of existing steel-wheel/steel-rail high-speed trains, expected maximum operation levels and speeds, and residential land use. The width of the potential impact along the length of the HST alignment is the area in which there is potential for noise impact. The FRA screening procedure was developed for HST speeds from 125 mph to 210 mph (201 kph to 338 kph). For speeds less than 125 mph (201 kph) and for areas near stations, the FTA screening method was used in concert with the FRA method. The FRA and FTA screening distances for noise are included in Appendix 3.4-A.

The screening distances are different for the different types of developed areas along a potential alignment according to their estimated existing ambient noise. “Urban” and “noisy suburban” areas are grouped together. These areas are assumed to have ambient noise levels greater than 60 dBA L_{dn}. Similarly, “quiet suburban” and “rural” or “natural open-space” areas are grouped as areas where ambient noise levels are less than 55 dBA L_{dn}. For developed land with L_{dn} between 55 and 60 dBA, the classification is dependant on other factors such as proximity of major transportation facilities and density of population. The screening procedure was applied to first allow for the comparison of impacts between alternatives and to identify areas of potential impacts for further consideration in project-level analysis. The screening procedure estimates the affected receptors to ensure that all potential impacts are included at the program level.

While the screening procedure is based on the type of equipment (technology and power type), operational characteristics of the new services (speeds and frequencies), the type of support structure (aerial or at grade), and the general ambient noise level, it does not address the horn and bell noise associated with existing passenger and freight trains because these are regarded as part of the existing environment and are assumed to be held constant for all three alternatives. To develop a relative comparison of the HST and Modal Alternatives, the results of the screening analysis were adjusted to account for noise reductions from the elimination of grade crossings on existing rail lines, where the HST alignment options would share the rail corridor. The degree of adjustment was based on the representative typologies for similar circumstances and is defined in the following section.

As a final step for those areas rated medium or high for potential impacts, the screening analysis assessed the potential use of noise barriers and other mitigation options to assess the potential for reducing noise impacts. The mitigation analysis is discussed in Section 3.4.5.

Vibration impact screening was performed for the HST Alternative only. The highway and aviation modes are assumed to cause less-than-significant ground-borne vibration, and neither FHWA nor FAA have adopted vibration impact assessment criteria. The vibration screening procedure is used to compare potential impacts among regional HST alignment design options and to provide an estimate of the length of alignments where consideration of vibration attenuation features may be appropriate.

Representative Typologies for High-Speed Trains

To better understand the potential impacts of the HST Alternative, several noise impact assessment studies were prepared for representative situations of noise- and vibration-sensitive land uses. The more detailed General Assessment Method of FTA’s and FRA’s guidance manuals were used to provide noise impact estimations. The FRA and FTA noise impact criteria of *severe impact*, *impact* and *no impact* were applied to the results. These typological studies verified the general results from the screening procedure. Representative situations were chosen to provide a range of potential impact types and levels. This approach provides a means of considering at the program level the potential impacts on communities along any potential proposed HST alignment. The typology locations are illustrated on maps by region in Appendix 3.4-F.

Developed land use categories consist of individual medium- and low-density residential zones, schools, hospitals, parks, and other unique institutional receptors such as museums, libraries, etc.

Residential land uses were chosen for the typologies for new and shared corridors that varied in local zoning densities, ambient noise conditions, set back distances from the alternative corridors, and HST operational speeds. Institutional uses as mentioned above and parks were individually identified for each focused study. These representative typologies were evaluated on the topics listed below.

- Verification of screening distances (noise and vibration).
- Effectiveness of noise barriers.
- Benefits from elimination of grade crossings.
- Costs and benefits of a high-speed downtown bypass loop.

Verification of Screening Distances (Noise and Vibration)
The results of the representative typologies confirm that the screening method used an appropriate upper boundary as an indicator of potential for noise impact. Impacts were found to occur in 90% of the cases identified in the screening procedure; in 75% of those studied, consideration of mitigation may be appropriate. Those that would have insignificantly low noise impact were either at outer edges of the screening distance or were shielded sufficiently by other buildings. Shielding by terrain features or buildings is not taken into account in the screening process, except to indicate some receptors would not need further analysis.

Representative studies were also completed that assess the range of the potential vibration impact levels that are likely to be encountered in project-level analyses. The results generally show that the nearer buildings would be to a proposed alignment, the greater the likelihood of impact. Where speeds are expected to be low, the vibration potential impacts are confined to within 100 ft (30 m) of the track. At top speeds, the potential impacts extend to 200 ft (61 m). The special typologies generally validate the vibration screening distances that are included in Appendix 3.4-A.

Effectiveness of Noise Barriers
Noise barriers are used extensively in Europe and Japan to mitigate noise impacts from HST systems. The representative typology studies generally indicated that mitigation by sound barrier walls can be an effective means of reducing the potential impacts by one category, for example, from severe impact (mitigation appropriate) to impact. Noise barrier mitigation is shown to be especially effective for receivers close to the tracks. While noise barrier walls would not be the only potential mitigation strategy to be considered, they were used to represent mitigation potential in this Program EIR/EIS.

Benefits from Elimination of Grade Crossings
The representative typology studies were also used to estimate the potential benefit of noise reduction resulting from grade separations. A focused noise study in the Bay Area to Merced region (at Charleston Road in Palo Alto) showed the potential benefit of eliminating horn blowing at a typical Caltrain grade crossing on the Peninsula. Assessment of noise impact from horns at grade crossings was performed with FRA's horn noise model and annoyance based criteria. The horn noise model indicated an 81% reduction in the number of people impacted within 0.25 mi (0.40 km) of that intersection by elimination of horn noise from commuter trains. Another focused noise study in the Los Angeles to San Diego via Orange County region showed similar results. The elimination of the grade crossing at Tamarak Street in Oceanside was analyzed and found to result in a 77% reduction in the number of people impacted in the vicinity. Although the results vary depending on the local population density and proximity of residences and other sensitive land uses at each grade crossing, they illustrate the magnitude of the potential change to be expected if the sounding of horns and bells at existing rail crossings could be eliminated.

Removing all potential remaining horn noise would not eliminate noise impacts, however, because the sound of the trains would remain. The proposed HST would add its own noise to that of other trains using the railroad corridor. Carrying the focused study further, it was found that approximately 75% of the grade crossings to be eliminated with the proposed HST are located adjacent to residential areas with a high potential noise impact rating. There would be a clear benefit from the elimination of the horns and warning signals. While with the HST, there would be additional train noise and vibration primarily from the high train speed and frequency of service.

Based on these results, the potential noise impact ratings from screening were adjusted to account for segments where grade crossings would be eliminated for existing passenger and freight trains as part of the implementation of HST service along that segment. A reduction in one impact rating level (high to medium or medium to low) was made only for segments where HST speeds would be less than 150 mph (241 kph). Where speeds are above that level, no adjustment was made since the noise created by the proposed new service at higher speeds would likely overshadow the reduction in horn and bell noise due to grade separation.

This adjustment was made on the segments listed below.

- Caltrain corridor from San Francisco to San Jose.
- Hayward/Niles/Mulford Line from south of Oakland to north of Union City.
- Metrolink/UPRR from south of Sylmar to Burbank.
- LOSSAN from Fullerton to north of San Juan Capistrano.
- LOSSAN from Oceanside to Solana Beach.
- LOSSAN from University Towne Centre to the northern portion of Mission Bay.

Costs and Benefits of a High-Speed Bypass Loop

The HST Alternative has rail alignment options that would allow express trains to bypass certain intermediate stations in urban centers. Such bypass tracks are referred to as express loops. The costs and benefits of express loops are based on the analysis of one line through the city (express tracks and off-line station tracks) versus two lines for the city (line through the city for stopping trains at reduced speeds < 125 mph [200 kph] and express tracks bypassing the urban area at high speeds). Without a high-speed loop, there is a greater potential for noise impacts on people in urban areas because of the higher speed of express trains, the greater number of trains, and the greater density of people along urban alignments. Express loops considered skirt the populated areas of several cities in the Central Valley, including Modesto, Atwater, Merced, Fresno, and Tulare. A noise analysis for the Sacramento to Bakersfield region was used to quantify and compare the differences between the two configurations, i.e., with and without high-speed loops.

The high-speed loop that skirts Fresno was chosen as an example to illustrate the potential noise benefits that might be obtained by implementing high-speed loops. The focused evaluation compares the number of people impacted by the option without the loop and the number of people impacted by the option that includes the high-speed loop around Fresno. Fresno has two potential high-speed loops, depending on which of the two rail alignments is selected as the mainline HST route, Union Pacific Railroad (UPRR) or Burlington Northern Santa Fe (BNSF).

The screening distance used for the high-speed loop is the distance associated with express high-speed trains at a maximum operating speed of 220 mph (354 kph). With the high-speed loop included as part of the option, the screening distance used for the mainline is that associated with stopping or accelerating trains at the station, or speeds slower than 125 mph (201 kph). Using the GIS database, the numbers of people potentially impacted for the two scenarios were determined.

The UPRR alignment high-speed loop option analysis indicates that if express trains use the mainline track (no high-speed loop), the number of people potentially impacted by noise would be somewhat higher (16%) particularly in the downtown area compared to the number of people potentially impacted by including a high-speed loop. The BNSF high-speed loop option analysis indicates that 12% more people would be potentially impacted if all trains use the mainline compared with the high-speed loop option. This comparative evaluation shows that fewer people would be impacted by noise with the high-speed loop, although the difference would not be large. While the high-speed loops would reduce noise impacts along the HST line through the urban center, the implementation of two lines (express loop and stopping tracks in the city) creates some additional noise impacts around the outskirts of the urban area and would affect a greater total area. The marginal reduction in potential noise impact in the urban locations from using an express (high-speed) loop might be achieved at a lower cost through noise barrier mitigation of the direct route in which all the trains (both stopping and express trains) pass through all the stations in urban areas.

3.4.2 Affected Environment

A. STUDY AREA DEFINED

The study area for the noise and vibration assessment is defined by the screening distances that are used by the FRA (U.S. Department of Transportation 1998) and FTA (U.S. Department of Transportation 1995) to evaluate rail and highway corridors. Rail and highway study areas are within 1,000 ft (305 m) of the centerline of the alignment options for each alternative. For airport noise in California, the study area is the area within the 65-decibel (dB) CNEL noise contour established for the particular airport. This is the extent of the area where a change in noise would be most noticeable to receptors, and noise impacts from new projects could begin to dominate the noise environment.

B. GENERAL DISCUSSION OF NOISE AND VIBRATION

This section describes the characteristics and associated terms and measurements used for transportation-related noise and vibration. When noise from a highway, plane, or train reaches a receptor, whether it is a person outdoors or indoors, it combines with other sounds in the environment (the ambient noise level) and may or may not stand out in comparison. The distant sources may include traffic, aircraft, industrial activities, or sounds in nature. These distant sources create a background noise in which usually no particular source is identifiable and to which several sources may contribute, but is fairly constant from moment to moment and varies slowly from hour to hour. Superimposed on this slowly varying background noise is a succession of identifiable noisy events of relatively brief duration. Examples include the passing of a train, the over flight of an airplane, the sound of a horn or siren, or the screeching of brakes. These single events may be loud enough to dominate the noise environment at a location for a short time, and when added to everything else, can be an annoyance. The descriptors used in the measurement of noise environments are summarized below.

The fundamental measure of noise is the dB, a unit of sound level based on the ratio between two sound pressures—the sound pressure of the source of interest (e.g., the HST) and the reference pressure (the quietest sound that a human can hear). Because the range of actual sound pressures is very large (a painful sound level can be over 1 million times the sound pressure of the faintest sound), the expression of sound is compressed to a smaller range with the use of logarithms. The resulting value is expressed in terms of dB. For example, instead of a sound pressure ratio of 1 million, the same ratio is 120 dB.

The human ear does not respond equally to high- and low- pitched sounds. In the 1930s, acoustical scientists determined how humans hear various sounds and developed response characteristics to represent the sensitivity of a typical ear. One of the characteristics, called the *A-curve*, represents the sensitivity of the ear at sound levels commonly found in the environment. The A-curve has been standardized. The abbreviation dBA is intended to denote that a sound level is expressed as if a measurement has been made with filters in accordance with that standard.

- *Maximum Sound Level (L_{max})*, measured in dBA, is the highest noise level achieved during a noise event.
- *Equivalent Sound Level (L_{eq})*, measured in dBA, describes a receptor's cumulative noise exposure from all noise events that occur in a specified period of time. The hourly L_{eq} is a measure of the accumulated sound exposure over a full hour. The L_{eq} is computed from the measured sound energy averaged over an hour (nothing one would read from moment to moment on a meter) representing the magnitude of noise energy received in that hour. FHWA uses the peak traffic hour L_{eq} as the metric for establishing highway noise impact.
- *Day-Night Sound Level (L_{dn})* describes a receptor's cumulative noise exposure from all noise events that occur in a 24-hour period, with events between 10 p.m. and 7 a.m. increased by *10* dB to account for greater nighttime sensitivity to noise. The L_{dn} is used to describe the general noise environment in a location, the so-called "noise climate." The unit is a computed number, not one to be read from moment to moment on a meter. Its magnitude is related to the general noisiness of an area. EPA developed the L_{dn} descriptor and now most federal agencies, including the FRA, use it to evaluate potential noise impacts. Typical L_{dns} in the environment are shown in Figure 3.4-1.
- *CNEL*, a variant of Ldn, is used in noise assessments in California. Rather than dividing the day into two periods, daytime and nighttime, CNEL adds a third to account for increased sensitivity to noise in the evening when people are likely to be engaged in outdoor activities around the home. An evening addition of 5 dB is applied to noise events between the hours of 7 p.m. and 10 p.m. to reflect the additional annoyance noise causes at that time. In general, the difference between Ldn and CNEL is slight and the two measures will be considered interchangeable for purposes of this noise analysis.

The way people react to noise in their environment has been studied extensively by researchers throughout the world. Based on these studies, noise impact criteria have been adopted by the FRA (U.S. Department of Transportation 1998) and other federal agencies to assess the contribution of the noise from a source like HST to the existing environment. The FRA bases noise impact criteria on the estimated increase in L_{dn} (for buildings with nighttime occupancy) or increase in L_{eq} (for institutional) buildings caused by the project for direct and indirect impacts. Criteria are discussed in Section 3.4.1 and Appendix 3.4-C.

Transportation Noise
Noise from highways, airports, and rail lines tends to dominate the noise environment in its immediate vicinity. Each mode has distinctive noise characteristics in both shape and source levels. Highway and rail noise affects an area that is linear in shape, extending to both sides of the alignment. Airport noise, in contrast, affects a closed area around the facility, with the shape of the closed loop determined by runway orientation.

Highway Noise and Vibration: Individual highway vehicles are generally relatively quiet, but the accumulation of noise from the volume of traffic throughout the majority of the day and night results in a nearly continuous high sound level. Noise from road traffic is generated by a wide variety of vehicle types, makes, and models. In general, the noise associated with highway vehicles can be divided into three classes of vehicle: automobiles, medium trucks, and heavy trucks. Each class has its own noise characteristic depending on vehicle type, speed, and the condition of the roadway surface.

The cumulative effect of all the vehicles added together comprises the noise environment in the vicinity of a highway. The noise level along a highway facility is strongly influenced by the traffic flow—its speed and the number of vehicles of each type using it. Busy freeways have a nearly continuous noise, whereas rural roads have noise levels that rise and fall depending on clusters of traffic. Multi-lane freeways spread the noise sources out over many lanes, resulting in a large area affected by noise. However, highway noise is generated at or very near the ground surface so that topographical conditions at the roadside have a major effect on propagation. Highway noise is described as a line source, since the noise is generated along a long line of highway. Noise levels are mapped using contour lines for given noise levels and they are roughly parallel to the highway. While these contours are directly influenced by the width of the facility (number of lanes), the volume and speed of the traffic are the primary factors that influence the amount of noise and the location of the noise contour.

Vibration created by truck traffic can be felt in areas adjacent to highways. However, there are no established vibration criteria for highways and consequently highway vibration is not part of this analysis.

Aircraft and Airport Noise and Vibration: Airport noise sources can be among the loudest sounds in the environment, but the aircraft pass-bys tend to be rather short in duration and are concentrated along the alignments of the runways. The area of noise impact around an airport depends on the number of operations, the type of aircraft, and the flight tracks used at that airport. Noise near airports is generated by a complex sound source consisting of flight operations and ground operations. Flight operations associated with an airport include takeoffs and landings, requiring extra power, and increased noise levels. When the aircraft are airborne, they propagate sound to great distances. For airborne operations, sound reaching the ground depends highly on atmospheric conditions. Ground operations include aircraft taxiing, run-up operations, and surface transportation near the terminal and its runways. Noise generated by ground operations has to spread out over the ground, thereby being strongly affected by topographical conditions, vegetation, ground types, and buildings.

Noise levels can vary considerably for different types of aircraft, by type, engine power settings, and flight paths. As with highway noise, the cumulative effect of airport noise depends on the number of flight operations and runway utilization. As opposed to a highway where the source is linear in nature, an airport is described as an aerial source, affecting a defined area with closed contours around the airport. The noise contours tend to be elongated in the direction of the major runways.

Vibrations from aircraft, particularly low flying aircraft and their engines, can potentially impact homes and businesses; however since the FAA does not have a criteria for measuring these vibrations, it is not included in this analysis.

Conventional and High-Speed Train Noise and Vibration: While high-speed trains have some similar noise and vibration characteristics to conventional trains, they also have several unique features resulting from the reduced size and weight, the electrical power, and the higher speed of travel. The proposed HST would be a steel-wheel, steel-rail electrically-powered train operating in an exclusive right-of-way. Because there would be no roadway grade crossings, the annoying sounds of the train horn and warning bells would be eliminated. The use of electrical power cars would eliminate the engine rumble associated with diesel-powered locomotives. The above factors allow HST to generate lower noise levels than conventional trains at comparable speeds below 100 mph (161 kph). At higher speeds above 150 mph (241 kph), however, HST noise levels would increase over conventional trains due to aerodynamic effects. A mitigating factor is that high speeds would enable HST noise to occur for a relatively short duration compared with conventional trains (a few seconds at the highest speeds versus 10 to 20 seconds for conventional passenger trains and over 1 minute for freight trains).

For the proposed HST system higher operating speeds of 150 to 220 mph (241 to 354 kph) would be planned for the less constrained areas, in terms of alignment (i.e., flat and straight). In contrast, much lower operating speeds <125 mph (201 kph) would be planned in the more developed areas. Figures 3.4-2 and 3.4-3 illustrate the maximum operating speeds for express service along each of the proposed HST alignment options. Local and semi-express services would not necessarily reach these maximum speeds because they would stop and start for more stations.

Noise from a high-speed train is expressed in terms of a source-path-receiver framework as illustrated in Figure 3.4-4. The source of noise is the train moving on its tracks. The path describes the intervening course between the source and the receptor wherein the noise levels are reduced by distance, topographical and human-made obstacles, atmospheric effects, and other factors. Finally, at each receptor, the noise from all sources combine to make up the noise environment at that location.

The total noise generated by a train is the combination of sounds from several individual noise-generating mechanisms, each with its own characteristics, including location, intensity, frequency content, directivity, and speed dependence. The distribution of noise sources on a typical HST is shown in Figure 3.4-5. These noise sources can be grouped into three categories according to the speed of the train.

For low speeds, below about 40 mph (64 kph), noise emissions are dominated by the propulsion units, cooling fans, and under-car and top-of-car auxiliary equipment such as compressors and air conditioning units. The HST would be electrically powered and considerable quieter at low speeds than conventional trains that are usually diesel powered.

In the speed range from 60 mph to about 150 mph (98 kph to 241 kph), mechanical noise resulting from wheel/rail interactions and structural vibrations dominate the noise emission from trains. In the existing rail corridors within California, conventional trains seldom exceed 79 mph (127 kph), so this speed range, which represents a medium range for HST, is the top end of noise characteristics for trains with which most people are familiar. Speed has a strong influence on noise in the medium speed range.

Above approximately 170 mph (274 kph), aerodynamic noise sources tend to dominate the radiated noise from the HST. Conventional trains are not capable of attaining such speeds. HST noise in the transition speeds between each of the three foregoing ranges is a combination of the sources in each range.

Noise from HST also depends on the type and configuration of its track structure. Typical noise levels are expressed for HST at grade on ballast and tie track, the most commonly found track system. For trains on elevated structure, HST noise is increased, partially due to the loss of sound absorption by the ground and partially due to extra sound radiation from the bridge structure. Moreover, the sound from trains on elevated structures spreads about twice as far as it does from at-grade operations of the same train, due to raising the sound source higher above ground.

Horns are an example of a train noise source that is a dominant noise source at any speed. Audible warnings at grade crossings, including train horns and warning bells, are a common feature of conventional trains and a vital safety component of railroad operations. These noise sources often prove to be a source of annoyance to people living near railroad tracks. In the case of HST, however, horn and warning bell noise at grade crossings are absent except in the case of emergencies because grade crossings are eliminated for reasons of safety. Elimination of horns and bells at existing grade crossings would provide a noise benefit associated with the implementation of HST for alignments along existing rail corridors, but only in locations where grade separations also served the existing rail service, thereby removing the need for grade crossing warnings and train horns.

Vibration of the ground caused by the pass-by of the HST is similar to that caused by conventional steel wheel/steel rail trains. However, vibration levels associated with the HST are relatively lower than conventional passenger and freight trains due to new track construction and smooth track and wheel surfaces resulting from high maintenance standards required for high-speed operation.

Ground-borne vibration from trains refers to the fluctuating motion experienced by people on the ground and in buildings near railroad tracks. In general, people are not commonly exposed to vibration levels from outside sources that they can feel. Little concern results when a door is slammed and a wall shakes or something heavy is dropped and the floor shakes momentarily. Concern results, however, when an outside source like a train causes homes to shake. The effects of ground-borne vibration in a building located close to a rail line could at worst include perceptible movement of the floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. None of these effects is great enough to cause damage, but could result in annoyance if repeated many times daily.

As with noise, ground-borne vibration can be understood as following a source-path-receptor framework, as shown in Figure 3.4-6. The source of vibration is the train wheels rolling on the rails. They create vibration energy that is transmitted through the track support system into the track bed or track structure. The path of vibration involves the ground between the source and a nearby building. The receptor of vibration is the building.

Mode Noise Level Comparisons

Noise levels of typical individual transportation vehicles are compared in Figure 3.4-7 with each other and with other commonly experienced sounds in the environment. Jet aircraft are clearly the noisiest of the transportation sources, followed by train horns and diesel trucks. Noise levels of high-speed trains at speeds of 100 to 150 mph (161 to 241 kph) are similar to that of freight and commuter trains at speeds of 50 to 80 mph (80 to 129 kph). The descriptor for the figure is the L_{max} which represents the highest sound level associated with a single event such as the passage of a train, aircraft, or truck.

As described above, the descriptor used in environmental assessments is the L_{dn}, which represents the cumulative noise exposure during a 24-hour period, rather than the L_{max}. A comparison of noise associated with surface transportation sources at various distances on either side of an unobstructed highway or railway is shown in Figure 3.4-8. This example is based on conventional passenger and freight trains at typical operating speeds compared with high-speed trains at a range of speeds, for a hypothetical situation of one train per hour. The graph shows the relative differences between these types and speeds of trains in terms of cumulative noise exposure. The graph also includes the cumulative noise levels over a 24-hour period of an 8-lane freeway with traffic traveling at 65 mph (105 kph) in relation to the train examples.

The graph in Figure 3.4-9 shows the difference in cumulative noise exposure for the same train types and speeds given typical frequency levels. In this case, since commuter trains and high-speed trains share many of the same noise profile characteristics (frequency, relative speed, and length) commuter trains and high-speed trains are assumed to have much higher frequencies than freight trains based on typical commuter operations and conceptual operating assumptions for HST. For this illustration, HST is assumed to have 118 day and 14 night trains made up of 1 power car and 15 coaches; commuter trains are assumed to have 46 day and 28 night trains made up of 1 locomotive and 5 coaches; and freight trains are assumed to have 10 day and 3 night trains made up of 2 locomotives and 40 freight cars. The 8-lane freeway in this and the preceding plot is assumed to carry 1,885 vehicles/hour/lane with 2% medium trucks and 3% heavy trucks. This example shows that as frequencies and speeds are increased (e.g., the addition of HST trips) the noise exposure is increased relative to the existing conventional rail services. Again, the graph includes the cumulative noise levels of a typical 8-lane freeway with traffic traveling at 65 mph (105 kph) in relation to the train examples. This example also shows how the cumulative noise diminishes with distance from the linear-type surface transportation sources. In the first 300 ft (91 m) from the centerlines, L_{dn} from rail sources tends to diminish more with respect to distance than that from a busy freeway. The freeway constitutes a continuous long source of noise, whereas a rail line has a series of transient noise events with relatively short sources.

Because of its aerial nature, airport noise cannot be represented in the same format used for surface transportation sources. Contours of noise exposure surround the airport in an irregular pattern depending on the orientation of its runways and their use. The frequency of operations (takeoffs and landings) has a direct impact on the noise levels in the vicinity of the airports. The area within each contour grows with the number of operations of aircraft. For example, the area of the L_{dn} 65-dBA airport noise contour used as the impact criterion in FAA's planning guide increases 17% (affecting additional land area) for every 1.5-dB increase in L_{dn} (approximately a 40% increase in number of operations), according to FAA's area equivalent method.

C. NOISE ENVIRONMENTS BY REGION

Regional noise and vibration environments are generally dominated by transportation-related sources, including vehicle traffic on freeways, highways, and other major roads, existing passenger and freight rail operations, and aviation sources, including civilian and military. Existing noise along highway and proposed HST corridors has been estimated using data in the noise element from the general plan for cities and counties in the region, along with general methods provided by FHWA, FRA, and FTA for estimating transportation noise. Ambient noise levels are characterized for each region in the sections below. Ambient vibration conditions are very site-specific in nature and are not characterized as part of the program environmental process.

Bay Area to Merced

This region includes central California from the San Francisco Bay Area (San Francisco and Oakland) south to the Santa Clara Valley and east across the Diablo Range to the Central Valley. The ambient noise in the northern portion of the Bay Area to Merced region is dominated by motor vehicle traffic in densely populated areas and along freeways. All the regional freeways considered in the No Project and Modal Alternatives are major contributors to the ambient noise environment. In this region the potential HST alignments would primarily follow or parallel existing rail tracks. Along the proposed HST alignment on the San Francisco Peninsula, the existing Caltrain passenger service is a major contributor to the ambient noise levels, especially at grade crossings where horn noise dominates the noise environment within 0.25 mi (0.40 km) of the intersections. Along the proposed HST alignment in the East Bay, existing Amtrak passenger service and freight rail contribute to the ambient noise levels, with horns at grade crossings being a major factor. In southern San Jose and as far as Gilroy to the south, Caltrain, Amtrak, and freight rail are major contributors to the ambient noise levels.

In the urban areas and suburban areas of the East Bay, San Francisco Peninsula, and San Jose, the ambient noise is estimated to range from L_{dn} 57 to 66 dBA. In many of the residential areas close to the international airports at San Francisco (SFO), Oakland (OAK), and San Jose (SJC), the ambient levels exceed L_{dn} 65 dBA. In the more rural areas of the region to the southeast, the ambient noise ranges from 52 to 57 dBA. Henry Coe State Park is characterized by a low ambient noise environment, approximately L_{eq} 40 dBA, being in a remote location and removed from transportation noise sources, except along SR-152, which is also part of the Modal Alternative.

<u>Sacramento to Bakersfield</u>

This region of central California includes a large portion of the Central Valley (San Joaquin Valley) from Sacramento south to Bakersfield. The proposed HST alignment options in the Sacramento to Bakersfield region primarily follow two major railroad alignments, UPRR and BNSF. Most of the UPRR corridor runs parallel to SR-99. The proposed UPRR alignment generally has more populated land use development than the one following BNSF. The highway improvements included in the Modal Alternative are primarily focused on SR-99 and I-5. These railroad lines and the highways are major contributors to the ambient noise environment.

The land use along the corridor corresponds to a quiet suburban or rural area, changing into a noisy suburban or urban area primarily inside of the city and town limits such as Fresno and Merced, in the middle and at Sacramento and Bakersfield on each end, where typical moderate to high noise levels exist. Due to the proximity of the existing railroad and highway corridors to the proposed alignment/improvement options, the non-developed areas or areas of low population density are also relatively noisy. The non-residential, rural, and quiet suburban areas along the alignment options and existing transportation corridors in this region correspond primarily to agricultural land use where low noise levels predominate. There are some commercial and industrial areas next to the alignments, but only within the boundaries of the towns and cities. Ambient levels are estimated to be between L_{dn} 50 to 58 dBA for rural and quiet suburban, and L_{dn} 60 to 68 dBA for noisy suburban urban areas.

<u>Bakersfield to Los Angeles</u>

This region of southern California encompasses the southern portion of the Central Valley south of Bakersfield, the mountainous areas between the Central Valley and the Los Angeles basin, and the northern portion of the Los Angeles basin from Sylmar to downtown Los Angeles. The ambient noise from Bakersfield to Sylmar is dominated by motor vehicle traffic along the I-5 corridor and by both motor vehicle traffic and freight and passenger trains throughout portions of the Antelope Valley option. From Sylmar to Los Angeles Union Station (LAUS) the ambient noise is dominated by motor vehicle traffic and near rail lines by freight and passenger trains. The ambient noise levels in the densely populated urban areas and areas near existing highways or rail corridors range from L_{dn} 58 to 67 dBA or even higher. In the more rural areas of the region, the ambient noise levels range from L_{dn} 50 to 53 dBA.

<u>Los Angeles to San Diego via Inland Empire</u>

This region of southern California includes the eastern portion of the Los Angeles basin from downtown Los Angeles east to the Riverside and San Bernardino areas and south to San Diego generally along the I-215 and I-15 corridors. Between Los Angeles and Riverside, the ambient noise environment in the study area is dominated by a combination of noise from freeways, major roads, and existing railroads. With close proximity to a freeway or rail line, the transportation noise will typically dominate the local noise environment. Ambient noise in these areas ranges from L_{dn} 58 to 68 dBA.

Along portions of the alternative corridors between Riverside and Escondido, which follow I-15 and I-215, freeway noise is the dominant component of the existing ambient noise. Although this portion of the region is fairly rural, ambient noise near the existing highways is high. The most rural area of this portion is mountainous, where ambient noise ranges from L_{dn} 54 to 65 dBA.

The Escondido to San Diego portion of the Inland Empire region is less urban than the Los Angeles area, but major freeways and existing rail lines have similarly high local noise environments. Ambient noise in the Escondido to San Diego areas along the study corridors ranges from L_{dn} 55 to 68 dBA.

Los Angeles to San Diego via Orange County

This region includes the western portion of the Los Angeles basin between downtown Los Angeles and Los Angeles International Airport (LAX) and the coastal areas of southern California between Los Angeles and San Diego, generally following the existing LOSSAN rail corridor. The ambient noise in the northern portion of the region is dominated by motor vehicle traffic in densely populated areas and along freeways. Along the connection to LAX, and in particular near freeways, motor vehicle traffic dominates. Closer to the airport, aircraft noise becomes dominant.

Along the conventional rail alignment south from LAUS, existing passenger service (Amtrak, Metrolink, and Coaster) and freight rail contribute to the local noise. Throughout this portion of the region, roadway traffic also contributes to the ambient. Along the HST alignment, freight rail and motor vehicle traffic comprise the sources of ambient noise. Along the coast, local roadway traffic and passenger rail service contribute to the ambient noise conditions, most notably horn blowing at grade crossings. Freeway noise is the dominant noise source in this region.

In the urban areas and suburban areas of Los Angeles and northern Orange Counties, the ambient noise ranges from L_{dn} 63 to 68 dBA depending on the proximity to noise sources such as rail, roadway and airport. In the more suburban areas of the region, the ambient noise ranges from 58 to 63 dBA. Along the coast, the ambient noise environment ranges from L_{dn} 54 to 64 dBA depending on proximity to local noise sources.

3.4.3 Environmental Consequences

A. EXISTING CONDITIONS COMPARED TO NO PROJECT ALTERNATIVE

The No Project Alternative includes programmed and funded transportation improvements that will be implemented and operational by 2020 in addition to the existing conditions. These improvements are not major system-wide capacity improvements (e.g., major new highway construction or widening or additional runways) and will not result in a general improvement of intercity travel conditions across the study area.

For purposes of this analysis, it is assumed that there will be no additional noise and vibration impacts associated with the development of No Project as compared to existing conditions. The potential significant impacts associated with programmed projects would be addressed with mitigation measures in a manner consistent with existing conditions in accordance with the project-level environmental documents and approvals for the projects as prepared by the project sponsors. While the implementation of the No Project Alternative may result in some increases, any estimate of such increases would be speculative.

B. NO PROJECT ALTERNATIVE COMPARED TO MODAL AND HIGH-SPEED TRAIN ALTERNATIVES

The No-Project Alternative is used as the basis for comparison. It is assumed that any improvements associated with the proposed Modal and HST Alternatives would be in addition to No Project conditions.

The relative level of potential noise impact for the Modal Alternative is illustrated in Figures 3.4-10 and 3.4-11. The figures show the relative noise impact in terms of high, medium and low categories for all of the potentially improved highway segments included in this alternative. The Modal Alternative has over 200 mi (322 km) of highway segments with potential for high noise impacts. The segments of high potential impact generally result from the high total traffic volumes (existing plus the representative demand) and the capacity improvements associated with the Modal Alternative, which result in increased speeds and wider facility cross sections. The segments with existing noise barriers are assumed to have less than high potential because most improvements would include noise walls.

The noise levels for airports are not categorized as high, medium, and low. The available data indicate that the number of people affected by the aviation component is a small portion of the number affected by the Modal Alternative (see Appendix 3.4-D). Although aircraft and airport improvements contribute less to the Modal Alternative's potential noise impacts than the more extensive highway improvements, it should be acknowledged that noise from aircraft and airport operations can impact relatively large areas of land including large numbers of people surrounding the airport. Noise is one of the most prominent factors for the environmental acceptability of airport improvement or expansion and is often the limiting factor in the approval of such projects. There is typically strong community resistance to airport expansions due to noise issues. Many of the airports in urban areas like Burbank, San Jose, and Orange County all have operating restrictions based on the noise from the aircraft and the airport operations.

The relative level of potential noise impacts for the HST Alternative is illustrated in Figures 3.4-12 and 3.4-13. The figures show the relative noise impacts in terms of high, medium and low categories for all of the HST alignment options. The potential noise impact ratings account for the reduction of horn and bell noise associated with the elimination of grade crossings on existing rail lines, where appropriate.

The relative level of potential noise impact for each alternative is shown in Table 3.4-1 in terms of the total lengths of alignment (highway or HST) in each rating (high-medium-low) category. The sections of alignment options with high, medium, and low potential noise impact ratings for the HST Alternative are compared with the equivalent sections of the Modal Alternative. In addition, the potential impact ratings of HST alignments are shown without mitigation. The impact levels shown for the Modal Alternative assume that sound barriers (walls) are maintained or rebuilt along the segments of each improved highway where they currently exist. The results show the HST Alternative would have less total mileage of high potential for noise impact than the Modal Alternative. A full range of HST alignment options were assessed assuming a statewide system comprising the alignment options with the greatest potential for noise impact (GPI) and those with the least potential for noise impact (LPI).

Based on the percentage of total system-wide length that would experience potential high noise impacts, the HST Alternative is close to the Modal Alternative. For example, 14% of the improvements associated with the Modal Alternative are rated with a high potential for noise impact, whereas the HST Alternative ranges from 3% for LPI to 14% for GPI.

Table 3.4-1
Summary of Noise Impact Ratings for Alternatives

Length (miles) with Potential Noise Impact Ratings[a]									
	Modal[b]			HST (GPI)			HST (LPI)		
REGION	H	M	L	H	M	L	H	M	L
System-wide totals[c]	210	258	1040	107	181	484	21	111	601
System-wide percentage of total[c]	*14*	*17*	*69*	*14*	*23*	*63*	*3*	*15*	*82*
Bay Area to Merced	93	153	131	26	103	70	0	50	103
Sacramento to Bakersfield	26	63	611	11	23	258	5	3	284
Bakersfield to Los Angeles	23	0	199	13	10	88	6	17	114
Los Angeles to San Diego via Inland	68	42	100	57	45	68	10	41	100
LOSSAN	61	43	14	42	65	50	5	65	50

[a] See Appendix 3.4-B for rating method.
[b] Assumed with maintenance or replacement of existing highway noise mitigation.
[c] Totals without LOSSAN.

3.4.4 Comparison of Alternatives by Region

A. BAY AREA TO MERCED

Modal Alternative

Under the Modal Alternative, the noise impact ratings for the various highway segments range from high in the urbanized areas to low in the rural areas. Two areas of high impact are the I-880 corridor from I-238 to Fremont/Newark in the East Bay and the US-101 corridor from SFO to Gilroy going south from the Peninsula. In both locations the highway and freeway corridors are adjacent to residential areas. The corridors from San Francisco over the bridge to I-880 and south to SFO have medium noise impact ratings because of less sensitive land uses adjacent to the freeways in those areas. The part of the region from Gilroy to Merced has low population density, which results in a low potential noise impact rating. Noise impacts on wilderness areas would also be relatively low since the highway improvements identified are expansions of existing facilities (noise corridors).

Increases in railroad operations are another potential source of noise impacts for the Modal Alternative. Potential noise impacts in residential areas are caused by increased train operations and by horns and bells at grade crossings. Commuter rail operations by Caltrain on the Peninsula and, to a lesser extent, Amtrak and freight operations on East Bay are major contributors. However, the change in projected commuter/intercity rail operations between Modal and No Project Alternatives is anticipated to be relatively small compared to the significant increases in highway traffic that will have a greater effect on noise.

The Modal Alternative included a new runway for both Oakland and San Jose airports to accommodate intercity traffic in lieu of HST. Adding runways in a dense urban environment would affect large additional areas due to the size of the physical improvement as well as the increased noise level associated with the improvement. In San Jose, an additional runway would impact a large area of residential and commercial land uses. In Oakland, the increased number of operations would impact the noise levels in surrounding areas. Overall, the Modal Alternative would have a greater number of miles with a high impact rating than the HST Alternative, although the total number of people newly impacted would not be as great in this region, primarily due to prior exposure from the existing highway, rail and air noise components.

High-Speed Train Alternative

The existing Caltrain alignment along the San Francisco Peninsula and the East Bay railroad alignments pass through densely populated communities where there is high potential for noise impacts. The potential noise impacts of the proposed HST service through these areas would result primarily from the greater frequency of trains, since the HST service would be operating at reduced speeds and would create similar noise levels to the existing services. The HST system would be expected to result in the elimination of up to 48 grade crossings on the Peninsula and up to 38 grade crossings on the East Bay. Grade separation of existing rail services would result in considerable benefits from the elimination of the warning bells at existing at-grade crossings and the horn blowing of the existing commuter/intercity services along these alignments. Although the HST service would be going through densely populated communities, the Caltrain alignment and the Hayward/Niles/Mulford Line in the East Bay were rated as having a medium level of potential noise impacts because the HST would be traveling at reduced speeds, and the communities would benefit from grade separation improvements for existing services and electrification of the railroad.

Between San Jose and Gilroy, the HST is rated as having medium potential for noise impacts. While the HST system could reach speeds as great as 186 mph (299 kph) through this area, the densities are less than on the Peninsula or the East Bay, and the communities would receive considerable benefit from the elimination of up to 24 grade crossings.

All the options for mountain crossings between the Bay Area and the Central Valley are through sparsely populated areas, but would introduce new noise sources along corridors through wilderness areas where the alignment is at grade or elevated.

High-Speed Train Alignment Option Comparison

Of the two options in the East Bay, the Hayward/I-880 alignment was given a higher ranking for potential impacts than the Hayward/Niles/Mulford Line, since the former would be elevated and would add noise from the already grade-separated freeway corridor. However, the Mulford Line would pass through the Don Edwards Wildlife Refuge and would have more impacts on wildlife than the I-880 freeway option.

Between San Jose and Merced, the Pacheco Pass alignments have higher potential for community impacts than the Diablo Range direct crossing options because of the potential for noise impacts through the urban and suburban areas of south Santa Clara County. For the Pacheco Pass alignment options, the Morgan Hill/Caltrain/Pacheco Pass option would minimize potential noise impacts on Gilroy. The Diablo Range direct alignment through Henry Coe State Park at grade would have more potential impacts on wildlife than the other two Diablo Range options because these options would have about 5 mi (8 km) of additional at-grade track rather than tunnel in the wilderness area.

Serving both the Peninsula and the East Bay would increase the number of alignment miles for Bay Area noise impacts, but reduce the frequency of HST service to either side of the bay.

B. SACRAMENTO TO BAKERSFIELD

Modal Alternative

From Sacramento to Bakersfield the potential noise impacts would be generally low. One area of potentially high impact is the I-5 corridor from the middle of Stockton to I-5 due to the close proximity of residential land along this alignment segment. Two segments with a medium rating are along SR-99 south from Sacramento to Manteca and also south from Bakersfield to I-5. Overall, the Modal Alternative has a greater distance with a high impact rating than the proposed HST Alternative, although the total number of people newly impacted is not as great as other regions, primarily due to existing exposure to highway noise. These highway corridors are heavily used by truck traffic, which generates high noise levels through the evening hours.

Potential improvements at the Sacramento Airport and Fresno Airport would not be extensive in terms of additional land area required (additional runways) and would have low potential noise impacts.

High-Speed Train Alternative

Through the Central Valley most of the alignment options for the HST Alternative are rated as low potential noise impact, due generally to the sparseness of residential land use and the extent of open space along most of the length of the options—even though the proposed HST service would be operating at maximum speeds throughout most of the Central Valley. However, there are a number of locations throughout the San Joaquin Valley where the various alignment options pass through populated areas and have high potential noise impact ratings for short segments. Examples include portions of Sacramento, Fresno, Tulare, and Manteca that could be exposed to high noise levels from HST operations.

Through many of the cities in the Central Valley, the HST is proposed to be on aerial structure, primarily to reduce potential conflicts with freight railroad spur tracks or freight railroad yards. The vertical elevation of the aerial structure would allow potential noise impacts to extend further than they would at grade.

Through several of the urban areas, the HST mainline (express or high-speed) alignment could pass through the city or community or avoid it by passing through surrounding areas (primarily farmlands). A representative typology study of the proposed high-speed loop around Fresno concluded there would only be a 12% to 16% reduction in noise impacts by moving the high-speed mainline (express) tracks outside the urbanized areas. The relatively modest decrease in noise impacts is attributed to three factors: 1) there would be some residential impacts along the new express loop; 2) many of the land uses surrounding the freight line through downtown Fresno are industrial; 3) the express loop results in noise impacts on two corridors as opposed to one. Figure 3.4-14 shows the mainline alignment through Fresno and the express loop options together with the surrounding land uses.

All alignment options in this region would have a low potential vibration impact rating. A few short segments of populated areas would have medium potential vibration impact ratings.

HST Alignment Option Comparison

Between Sacramento and Bakersfield there are two potential alignment options for the proposed HST Alternative along railroad rights-of-way, UPRR and BNSF, along with some combinations. The UPRR alignment would have a considerably greater potential for noise impacts than the BNSF alignment. The UPRR alignment passes through much more urban area. The UPRR has more freight activity to the Central Valley cities it bisects, which results in more spur lines, service lines, and freight yards in these communities along the freight alignment. The proposed HST line would be grade-separated from these freight railroad facilities, typically on an elevated structure.

Therefore, the UPRR passes through more communities, and would require more elevated structures through these communities. The Central California Traction (CCT) alignment option would have fewer potential noise impacts than the UPRR alignment between Sacramento and Stockton because there are fewer residential areas near the alignment. South of Power Inn Road in Sacramento, both CCT and UPRR would be predominately at grade. Along the UPRR, some grade-separation benefits would result from reducing noise from the existing freight services, whereas the CCT is a recently abandoned freight corridor.

Between Stockton and Merced, the UPRR alignment would have much higher potential noise impacts than the BNSF alignment. UPRR goes through much more urban area as it passes through the cities and communities that developed around the railroad line, and is proposed to be on aerial structure through many of these communities. Conceptually, the alignment options along UPRR would have a substantial amount of aerial structure through Manteca, Modesto, Keyes, Turlock, and Atwater, whereas the alignment through Salida, Ceres, Delhi, Livingston, and Merced would be at grade. The alignment options along BNSF would have a substantial amount of aerial structure through Escalon and Riverbank. Through Riverbank, however, the downtown and most of the populated area would be at grade. BNSF would be at grade through the outskirts of Modesto (Briggsmore), Hughson, Denair, Winton, Atwater, and Merced. Much of the potential noise impact of BNSF may be offset by the noise benefits from grade separating the adjacent freight service when operating at grade.

Between Merced and Fresno, the UPRR alignment option would have higher potential noise impacts than the BNSF alignment. UPRR goes through more urban areas, and is proposed to be on aerial structure through these communities. Conceptually, the alignment options along the UPRR corridor have a substantial amount of aerial structure through both Chowchilla and Madera. The BNSF corridor does not go through much developed area between Merced and Fresno. The BNSF alignment options would be at grade through Le Grand and the outskirts of Madera. Much of the potential noise impact of BNSF may be offset by the noise benefits from grade separating the adjacent freight service when operating at grade. Through Fresno, only the UPRR alignment option is being considered for further evaluation. A majority of the UPRR alignment through Fresno is expected to be at grade.

Between Fresno and Bakersfield, the UPRR alignment option would have much higher potential noise impacts than the BNSF alignment option. However, BNSF would have more potential noise impacts through Bakersfield. UPRR goes through many more urban areas and is proposed to be on aerial structure through many of these communities. Conceptually the alignment options along the UPRR corridor would have a substantial amount of aerial structure through Selma, Traver, Goshen, Tulare, Pixley, and Delano, whereas the alignment through Fowler, Kingsburg (on aerial structure south of the Kingsburg urban area), Tipton, Earlimart, and McFarland would be at grade. The alignment options along the BNSF corridor would have a substantial amount of aerial structure through the outskirts of Corcoran, through Hanford, and Shafter, whereas the BNSF would be at grade through Laton. Through Bakersfield, a majority of the UPRR alignment option is at grade and travels through industrial land uses. The BNSF alignment option would include more aerial structure through Bakersfield and impact more residential areas than the UPRR alignment option.

Through Modesto, Merced, Fresno, and Tulare, the high-speed train mainline (express or high-speed) alignment could pass through the city or community or avoid it by passing through surrounding areas (primarily farmlands). As previously noted, the focused study on the high-speed loop around Fresno concluded there would only be a modest (12% to 16%) reduction in noise impacts by moving the high-speed mainline (express) tracks outside the urbanized areas. The Fresno typology is representative of the express loop bypass design options for other Central

Valley communities, and it is expected that the express loop design options for Modesto, Merced, and Tulare would yield similar results to the Fresno typology.

C. BAKERSFIELD TO LOS ANGELES

Modal Alternative

From Bakersfield to Los Angeles there would be more potential noise impacts in the urban areas such as Bakersfield and Los Angeles than in the rural areas. As the highway alternative crosses the sparsely populated Tehachapi Mountains potential noise impacts on residents would be minimal; however, there may be noise impacts on sensitive wildlife.

The expansion of the Burbank airport and the associated higher frequency of take offs and landings would have potential noise impacts in the area surrounding the airport. The addition of a runway would impact a large area of residential and commercial land uses and the increased number of operations would impact the noise levels in surrounding areas. Overall, the Modal Alternative's potential noise impacts would be expected to be greater than potential noise impacts from the HST Alternative. Because the highway would be expanded by as much as 6 lanes through the mountain passes and would not use tunneling, it would have substantial noise impacts on wildlife, recreational use of nature trails, and other outdoor recreation activities and uses.

High-Speed Train Alternative

The proposed HST Alternative would have low potential noise impact ratings between Bakersfield and Sylmar due to the sparseness of residential land use and the extent of open space along most of the two routes. Within Bakersfield, where HST express services would achieve maximum speeds, the two alignment options would pass through areas with residential population and have greater potential noise impacts. As the alignments near Los Angeles, the potential for noise impact increases as the population density increases. The alignment segment between Sylmar and Burbank would be expected to reach relatively high speeds as great as 186 mph (299 kph) and has a high potential for impact through Sylmar and a medium potential for impact through Burbank. Elimination of nine grade crossings between Sylmar and Los Angeles would result in noise reduction benefits to people who live near those crossings. South of Glendale, the proposed HST system would operate at reduced speeds. Most of the segment between Sylmar and Los Angeles is considered to have medium potential noise impacts because of the relatively long trench section proposed and the reduction in noise associated with the removal of grade separations over a long portion of this segment.

High-Speed Train Alignment Option Comparison

The HST Alternative has low potential noise impact ratings along both the I-5 and SR-58/Soledad Canyon alignment options due to the sparseness of residential land use and open space along most of these two routes. However, more of the SR-58/Soledad Canyon alignment option passes through populated areas. In addition, the I-5 alignment would require more tunneling through the open space and natural areas, which would result in fewer potential noise impacts on wildlife, hiking trails, and other outdoor recreational uses.

D. LOS ANGELES TO SAN DIEGO VIA INLAND EMPIRE

Modal Alternative

Between Los Angeles and San Diego along the inland routes, freeway traffic is extremely heavy throughout the area. The high population density in close proximity to the freeways between Los Angeles and San Bernardino/Riverside results in high noise impact ratings for that area. South of March Air Reserve Base (ARB) to Mira Mesa, the lower population density along the highway segments is reflected in a low noise impact rating. Potential noise impacts are rated as medium in the stretch from Mira Mesa to San Diego.

The expansion of the Ontario and San Diego airports and the associated higher frequency of takeoffs and landings would have high potential impacts on the noise levels in the areas surrounding the airports. An additional runway at each of these airports would impact large areas of residential and commercial land uses and the increased number of operations will impact the noise levels in surrounding areas. Overall, the number of potential noise impacts associated with the Modal Alternative falls between the HST GPI and with the LPI in this region.

High-Speed Train Alternative

The high population density in Los Angeles and San Bernardino/Riverside results in both medium and high noise impact ratings for the proposed HST Alternative throughout that area. However, compared to the freeway alignments, the rail alignments generally abut less sensitive industrial and commercial land uses that are less vulnerable to noise. There are also considerable stretches of grade-separation improvements that would reduce impacts from existing freight rail services along portions of the alignment. Between Pomona and Riverside, the UPRR Colton alignment is very straight and contains mostly industrial land uses where the HST system would be expected to achieve maximum speeds for this segment. South of March ARB to Mira Mesa, the lower population density along the I-215 and I-15 highway alignments is reflected in a low noise impact rating. South of Escondido, the HST service would largely be reduced to speeds of 125 mph (201 kph) or less because of alignment issues. Potential noise impacts are rated as medium and high in the stretch from Mira Mesa to downtown San Diego via either Miramar Road or Carol Canyon. All alignment options in this region have potential vibration impact ratings of medium or low.

High-Speed Train Alignment Option Comparison

The HST Alternative alignment option along the UPRR Colton Line (northern alignment option) alignment between Los Angeles and East San Gabriel Valley would have a high potential for noise impacts due to the proximity of residential land use along most of this route, whereas the UPRR Riverside/UPRR Colton alignment is largely surrounded by industrial land uses and is ranked as having a medium potential for noise impacts.

The alignment that would most directly serve San Bernardino would have considerably higher potential noise impacts than the UPRR Colton alignment because it would impact more residential areas. Between Ontario Airport and Colton, the UPRR Colton alignment is within a wide, sparsely developed industrial corridor.

From Los Angeles to March ARB, the low potential vibration rating would be along the UPRR Colton Line option, as compared to a medium rating along the UPRR Colton Line to San Bernardino, due to the lower population within the screening distance along the former alignment.

The Miramar Road alignment option from Mira Mesa to San Diego would have a higher potential noise impact rating than the Carol Canyon alignment option, which would traverse less populated areas. Both the Miramar Road and Carol Canyon alignments would have considerably higher potential noise impacts than the option along I-15 to Qualcomm Stadium. The Qualcomm Stadium option would also have a lower potential for vibration impacts.

E. LOS ANGELES TO SAN DIEGO VIA ORANGE COUNTY (LOSSAN)

Modal Alternative

Under the Modal Alternative, the potential for high noise impacts would occur along the I-5 corridor from downtown Los Angeles to Irvine and also in San Juan Capistrano, Encinitas, and San Diego. These potential noise impacts would be due primarily to the close proximity of residential land along these alignment segments. The coastal area south of Dana Point up to Encinitas would not be as highly impacted due to the relatively open agricultural areas along the freeways. The Modal Alternative would have generally greater impact than the proposed HST options through this region. South of Encinitas along the coastal areas to San Diego and across lagoons with sensitive habitat and numerous birds, the noise impacts of expanded highways would be added to existing noise levels.

High-Speed Train Alternative

The HST Alternative would be expected to have potential impacts that are high along the LAX connection alignment for the proposed HST and the UPRR Santa Ana alignment from Los Angeles to Anaheim. Although the proposed HST speeds along the LAX alignment would be well under 100 mph (161 kph), a new, frequent, passenger service would be introduced into a dense urban area, resulting in a new and significant noise source.

South of San Clemente the noise impact rating for conventional rail improvements would be low due to the presence of the U.S. Marine Corps base at Camp Pendleton. Through this area, non electric conventional rail service could reach speeds up to 150 mph (241 kph). At Oceanside the conventional rail alignment would encounter higher population densities and would represent medium potential impact from there through Encinitas. Maximum conventional speeds south of Oceanside would not be expected to exceed 100 mph (161 kph). All sub-options for the LOSSAN alignment from Encinitas to San Diego would have a low noise impact rating.

Overall, the LOSSAN alignment would receive benefits from grade crossing eliminations that would be part of the proposed improvements, including the potential conventional rail improvements for service south of Irvine. A major benefit is the elimination of horn noise at the grade crossings. Horn noise dominates the area within 0.25 mi (0.40 km) of a grade crossing, such that its elimination would more than make up for the increased train noise. It is estimated that potential noise impacts can be reduced by approximately 80% at adjacent receptors by eliminating freight and passenger train horns, according to the focused noise study results performed at a grade-crossing site in Oceanside.

High-Speed Train Alignment Option Comparison

The LOSSAN rail alignment between Los Angeles and Anaheim has a considerably lower noise impact rating than the UPRR Santa Ana alignment. The communities along the LOSSAN alignment would receive benefits from full grade separation due to the elimination of warning bells and train horn noise from existing services (Amtrak, Metrolink, and freight) along this heavily used rail line. In contrast, UPRR Santa Ana would be introducing a new, frequent, passenger service to a lightly used freight alignment.

Between Anaheim and Irvine, both the HST alignment option (to bring direct service to Irvine), and the high end conventional rail improvements option would result in a fully grade-separated LOSSAN rail alignment. The communities along the LOSSAN alignment (Orange, Santa Ana, and Tustin) would receive benefits from full grade separation due to the elimination of warning bells and train horn noise from existing services (Amtrak, Metrolink, and freight) along this heavily used rail line from these options. In contrast, the low end conventional rail improvements would permit additional frequencies of service, which would have additional noise impacts without the benefits of grade separation.

Of the two conventional rail options within San Juan Capistrano, the Trabuco Creek option would have a medium rating, whereas the tunnel under I-5 would have low potential impacts. Trabuco Creek would have some at-grade operations on the edge of the historic district, while the I-5 option would completely bypass historic San Juan Capistrano.

The long tunnel conventional rail concept through San Clemente would have a low potential for impacts since it completely removes the LOSSAN alignment from the sensitive coastal communities, and would place it in tunnel deep under I-5. The short tunnel conventional rail option is ranked as having medium potential impacts. This option would remove the LOSSAN alignment from the beach along San Clemente, resulting in significant benefits to that community. However, the short tunnel option would continue to utilize the coastal alignment along Dana Point. While there could be some noise improvement from grade separation (removal of warning bells and train horns), there may also be impacts from the potential future increases in train frequencies and speeds along Dana Point.

The short trench concept for conventional service through Carlsbad would have considerably fewer potential noise impacts for downtown Carlsbad than the option to leave several crossings at grade through downtown near the Carlsbad Coaster Station. The short trench concept would eliminate the train horn noise and remove the warning bells at the existing at-grade crossing. It would also place the alignment underground in a cut-and-cover tunnel, virtually eliminating train noise through the center of this coastal community. Leaving several crossings at grade through the town center would result in additional noise impacts from increases in rail service.

The short trench concept for conventional service through Encinitas, like Carlsbad, would have considerably fewer noise impacts for downtown Encinitas than the option to leave several crossings at grade through downtown near the Encinitas Coaster Station. The short trench concept would eliminate the need for train horn noise and remove the warning bells at the existing at-grade crossing. It would also place the alignment underground in a cut-and-cover tunnel, virtually eliminating train noise through the center of this coastal community. Leaving several crossings at grade through the town center would result in additional noise impacts from increases in rail service.

Both of the conventional rail tunnel concepts for Del Mar would be expected to have low potential noise impacts. While these concepts may result in some additional noise impacts (particularly at the portals), both concepts would provide considerable benefit to the community as a result of grade-separation improvements (the elimination of warning bells and train horn noise).

South of Irvine, the high end conventional rail improvements option would result in a fully grade separated LOSSAN rail alignment. The communities along the LOSSAN alignment would receive benefits from full grade separation by the elimination of warning bells and train horn noise from existing services (Amtrak, Metrolink, and freight) along this heavily used rail line. In contrast, the low end conventional rail improvements would permit additional frequencies of service, which would have additional noise impacts without the benefits of full grade separation.

3.4.5 Mitigation Strategies

General mitigation strategies are discussed in this programmatic review of potential noise impacts associated with proposed alternatives. More detailed mitigation strategies for potential noise and vibration impacts would be developed in the next stage of environmental analysis. Noise and vibration mitigation measures can generally be applied to the source (train and associated structures), the path (area between train and receiver) and/or the receiver (property or building). A new HST system would be designed and developed to meet state-of-the-art technology specifications for noise and vibration, based on the desire to provide the highest-quality train service possible. Trains and tracks would be maintained in accordance with all applicable standards to provide reliable operations.

Treatments such as sound insulation or vibration controls to impacted buildings may be difficult to implement for the potentially numerous properties adjacent to the right-of-way. Such treatments require protracted implementation procedures and separate design considerations. The most feasible and effective mitigation treatments are typically those involving the path. These mitigation measures can often be applied to the path within the right-of-way, either under or adjacent to the tracks. Potential noise impacts can be reduced substantially by the installation of sound barrier walls constructed to shield receivers from train noise. For vibration mitigation, a number of track treatments may be considered for reducing train vibrations. Determining the most appropriate treatment would depend on the site-specific ground conditions found along the corridor. This program-level analysis has identified areas where future analysis should be given to potential HST-induced vibrations.

A. NOISE BARRIERS

Noise barriers are often a practical way to reduce noise impacts from transportation projects including the proposed HST system. The representative typologies considered mitigation with noise barriers for certain areas. In most cases the potential noise impacts could be reduced from the severe impact category to the FRA's impact category, and to the no impact category in some locations, with the application of appropriately dimensioned noise barriers next to the tracks. The design of noise barriers appropriate for the proposed HST right-of-way line would depend on the location and height of noise-sensitive buildings, as well as the speeds of the trains. Noise barriers 8 to 10 ft (2 to 3 m) tall could be installed where speeds are relatively low such that wheel/rail noise dominates. Higher noise barriers of 12 to 16 ft (4 to 5 m) might be used to reduce noise to taller buildings, or where speeds are high in noise-sensitive areas. In many locations noise barriers could be installed on one side of the track only, due to he location and proximity of noise-sensitive areas.

Application of mitigation to the proposed HST system would result in a considerable reduction of potential noise impacts. The estimates obtained from the results of the representative typologies showed noise barriers to be effective in reducing the potential noise impact rating by one category, for example, from high to medium or from medium to low. Consequently, HST segments with high rating would be adjusted down to, at most, a medium rating. With mitigation applied to the HST Alternative, both the GPI and LPI scenarios would represent substantially lower levels of potential impacts as compared to the Modal Alternative.

To estimate the reduction in noise impacts, the percentage reduction in noise for each segment was applied to the total number of people impacted in that segment, assuming the mitigation removed that many people from being impacted. The number of people remaining in the impact category was then summed for each region and system-wide. The lengths of the routes requiring noise barriers were then tabulated to provide an estimate of the mitigation costs.

The cost of constructing a noise barrier on one side of a highway or a rail line is estimated at approximately $1 million per mi ($625,000 per km) for a concrete wall of 12 ft (4 m) in height. Conservatively, a unit cost of $1.5 million per mi ($937,500 per km) was applied to the alignment segments in the HST Alternative with high potential noise impact ratings. The procedure was repeated for all segments with a medium rating in addition to those with high rating, thereby reducing all HST noise impact ratings to low. The same costs were applied to the Modal Alternative for comparison using segment lengths with a high noise impact rating. This approach was intended to provide a rough estimate of potential mitigation costs, recognizing that specific mitigation would be developed as a part of project-level review.

The results in Table 3.4-2 show that potential mitigation costs for the HST Alternative, applied to the segments rated at high potential for noise impacts only, would be less than the costs of similar mitigation applied to the Modal Alternative. This analysis included noise mitigation (barrier walls) for 8 of the 731 route miles (13 of the 1,176 route km) of the proposed HST segments with LPI and 133 of the 773 route miles (214 of the 1,244 route km) with GPI. With mitigation applied to both high- and medium-rated segments, the HST potential impacts would be reduced further below the Modal Alternative, including noise mitigation (barrier walls) for 144 and 369 route miles (232 and 594 route km), for the LPI and GPI, respectively.

Table 3.4-2
Potential Length and Cost of Noise Mitigation[a] by Alternative

Alternative	Mitigation length in miles (km)	Noise Barrier Cost (millions)
MODAL—highway component (high level only)	210 (338)	$315
HST mitigating (high levels only)	8–133 (13–214)	$12–$200[b]
HST mitigating (high and medium levels)	144–369[b] (232–594)	$216–$554[b]

[a] Mitigation refers to barrier walls only.
[b] Range for LPI and GPI.

Not included in the costs for the Modal Alternative are noise abatement measures at airports that may involve extensive programs of sound insulation of homes. A typical sound insulation program limits the costs to approximately $30,000 per home. Referring to tables in Appendix 3.4-D where the number of people impacted by aviation noise is shown as approximately 12,000 people, and assuming there are four people to a house, the cost for noise mitigation around airports associated with the Modal Alternative could be an additional $90 million.

B. VIBRATION MITIGATION

Vibration mitigation is less predictable at a program level of analysis due to the site-specific nature of vibration transmission through soil conditions along the alignment. However, an estimate can be made of the length of corridor where special mitigation may need to be considered by totaling the segments with potential vibration impact rating of high. The results are shown in Appendix 3.4-E. The range is 10 to 60 mi (16 to 97 km) to be considered for mitigation depending on which alignment is chosen.

3.4.6 Subsequent Analysis

A. NOISE ANALYSIS

The FRA provides guidance for two levels of analysis in project environmental review, a general assessment method to further quantify the potential noise impacts in locations identified by the screening procedure, and a detailed analysis procedure for evaluating suggested noise mitigation at locations where further studies show there is potential for significant impacts. The process is designed to focus on problem areas as more detail becomes available during project development. Subsequent analysis would proceed along the following lines.

<u>Ambient noise conditions</u>
The existing ambient noise environment is described by assumptions in the screening procedure. However ambient noise values would be estimated at the project-level analysis based on limited

measurements in the general assessment and would be thoroughly measured in the detailed analysis. A measurement program involving both long-term and short-term noise monitoring would be performed at selected locations to document the existing noise environment. As it would be impractical to measure everywhere, the monitoring would be supplemented by estimates of noise environments at locations considered to be typical of others. Guidelines for characterizing the existing conditions are provided by the FRA.

Project Noise Conditions
A generic HST is used in the screening procedure, but a specified train type, speed profile and operation plan would be available for more refined projections of noise levels in the next stage of environmental analysis.

Noise Propagation Characteristics
The screening procedure assumes flat terrain with noise emanating from a source unhindered by landforms and human-made structures. The next stage of analysis would incorporate topography as well as consideration of shielding by buildings, vegetation, and other natural features in a particular corridor.

Impact Criteria
The screening procedure accounts for all noise-sensitive land use categories that may be exposed to noise levels exceeding the threshold of impact. In the next stage of analysis, assessments using the full, three-level FRA impact criteria would be performed (U.S. Department of Transportation 1998). This more detailed assessment would more specifically identify locations where potential impacts may occur and locations where potentially high impact may occur and would provide for consideration of specific mitigation measures where appropriate.

Mitigation
Noise abatement is discussed generally in the screening procedure, and areas are identified where more detailed analysis should be focused in the future to integrate a proposed HST system into the existing environment. As more detail becomes available in the general assessment phase, there may be many areas that were identified as potentially impacted during screening analysis for which further analysis would not be needed, because they would not be impacted. The detailed analysis would provide information useful for the engineering design of mitigation measures. These measures would be considered in the project-level environmental review, and potential visual and shadow impacts of noise barriers would also be considered.

B. VIBRATION ANALYSIS

The steps involved in the more detailed analysis of ground-borne vibration would be similar to those for noise. The major difference would be the need for study of site-specific ground-borne vibration characteristics. Considerable variation of soil conditions may occur along the corridor, resulting in some locations with significant levels of vibration from the HST and other locations at the same distance from the track where vibrations can hardly be perceived. Determining the potential vibration characteristics in the detailed analysis would involve a measurement program performed according to the method described in the FRA guidance manual (U.S. Department of Transportation 1998). This method would allow for the prediction of vibration levels and frequency spectrum information valuable not only in the assessment of impact, but also in the consideration of mitigation measures.